 GLAST LAT DESIGN SPECIFICATION	Document # **LAT-SS-00820-03**	Date Effective 11 Feb. 2003
	Prepared by(s) Eric Grove, Nick Virmani, Leif Nilsson	Supersedes None
	Subsystem/Office Calorimeter Subsystem	
Document Title **LAT Calorimeter CsI Crystal Performance Requirements**		

Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Calorimeter CsI Crystal Performance Requirements

DOCUMENT APPROVAL

Prepared by:

Eric Grove
Naval Research Lab
Date

Nick Virmani
Naval Research Lab
Date

Leif Nilsson
Kalmar University
Date

Approved by:

W. Neil Johnson
CAL Subsystem Manager
Date

Per Carlson
Kungl Tekniska Högskolan, Stockholm
Date

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes	DCN #
1	28-Jun-02	Initial Release	
2	20-Nov-02	Modifications to Crystal Drawing, LAT-DS-01115	
3	11-Feb-03	Incorporate Changes as suggested by Sweden	

TABLE OF CONTENTS

1 PURPOSE

This document specifies the performance of the Thalium-doped Cesium Iodide, CsI(Tl), scintillating crystals for the Calorimeter subsystem of the GLAST Large Area Telescope (LAT). It also includes the quality assurance and process controls requirements and acceptance test measurements. In this regard it supercedes the original CsI Crystal Specification, LAT-DS-00095-03 dated 5 April 2001. This document reflects and summarizes all the changes and clarifications in the CsI performance requirements that have occurred since the release of the original specification.

The GLAST calorimeter detector elements (CDE) contain a crystal of thallium-doped cesium iodide as active gamma absorption material, having the dimensions $326.0 \times 26.7 \times 19.9$ mm^3. These crystals are grown, cut and polished by the manufacturer Amcrys H in Ukraine. They are also individually wrapped and optically tested by the manufacturer before being shipped to Sweden. Test data are enclosed with the crystals and will be verified upon delivery in Sweden.

2 SCOPE

These specifications apply to the CsI(Tl) scintillation crystals for the Calorimeter subsystem of the GLAST LAT. The crystals shall support development models of the LAT calorimeter and 18 flight model calorimeter modules. Each module requires 96 CsI(Tl) crystals.

3 DEFINITIONS

3.1 Acronyms

CAL	The Calorimeter subsystem of the LAT
CsI or CsI(Tl)	Thalium-doped Cesium Iodide
FWHM	Full Width at Half Maximum
GLAST	Gamma-ray Large Area Space Telescope
EM	Engineering Model
FM	Flight Model
GSFC	Goddard Space Flight Center, NASA
KTH	Kungl Tekniska Högskolan
LAT	Large Area Telescope
MIP	Mandatory Inspection Points
NASA	National Aeronautics and Space Administration
NRL	Naval Research Laboratory
PIN	Positive-Intrinsic-Negative, a silicon device construction technique to provide low-capacitance, high speed photodiode response
TBD	To Be Determined
TBR	To Be Resolved

3.2 Definitions

γ	Gamma Ray
μm	micrometer
mm	millimeter
cm	centimeter
eV	Electron Volt
MeV	Million Electron Volts, 10^6 eV
ph	Photons

4 APPLICABLE DOCUMENTS

Documents that are relevant to the development of the GLAST LAT Calorimeter and its requirements include the following:

LAT-DS-00095-03	"LAT Calorimeter CsI Crystal Specification"
LAT-DS-01115-01	Drawing, "CsI Crystal, CAL CDE Flight"
LAT-PS-00809-01	"LAT Calorimeter Crystal Handling and Shipping Procedure"
LAT-DS-00096-01	"Calorimeter Crystal Mechanical Test Station Requirements"
LAT-PS-00254-01	"CsI Crystal Optical Test Bench Operating Procedure"
LAT-SS-00108-02	"CsI Crystal Optical Testing Station Software Requirements"
LAT-SS-00018-09	"LAT CAL Subsystem Specification – Level III Specification",
LAT-SS-00210-D3	"LAT CAL Subsystem Specification - Level IV Specification"
LAT-MD-00228-D2	GLAST LAT Calorimeter, Tracker, and Trigger & Data Flow Contamination Control Plan
GSFC-433-MAR-0004	"Mission Assurance Requirements (MAR) for Gamma-Ray Large Area Telescope (GLAST) Large Area Telescope (LAT)", NASA Goddard Space Flight Center,
NPD 8010.2B	"NASA Policy Directive, Use of Metric System of Measurement in NASA Programs"

5 SPECIFICATION CHANGE SUMMARY

Table 1 summarizes the changes reflected in this document in comparison with the original CsI Crystal Specification, LAT-DS-00095-03.

Table 1. Specification Changes

Specification	(this document) LAT-DS-00820-02 Paragraph No.	LAT-DS-00095-03 Paragraph No.	Comment
Crystal Length	7.1.1	6.1.1	New length, 326 mm. Tolerances unchanged
Chamfer Specification and Control	7.1.2	6.1.2	Chamfer specification is controlled by separation of opposing edge chamfers, not chamfer width.
Light Yield Uniformity	7.2.3	6.2.2	Clarification of average measurement.
Light Asymmetry Measure	7.2.5	(none)	An additional characterization of the light tapering originally specified in 6.2.3. The required measurements are automatically provided by the optical test bench.
Crystal Identification	8.1.2	7.1.2	Specification of wrap label relative to crystal orientation. Addition of physical mark on crystal to identify orientation.
Crystal Handling	8.2	(none)	Finished crystal handling
Inspection and Testing	8.3	(none)	Quality assurance provisions.
Record control	8.4	7.9	Maintenance of records of tests and quality control. Documentation of non-conformance.
Acceptance Data package	8.5	7.5 – 7.8	Data required w/ Crystal deliveries
Handling and Shipping	9 - 10	8	
Finished Crystal Dimension Drawing	Figure 1	Figure 1	Details of final polished crystals

6 INTRODUCTION

The GLAST LAT calorimeter is comprised of a hodoscopic array of CsI(Tl) scintillation crystals. Scintillation light is collected by PIN photodiodes and processed by charge sensitive preamps. The CAL subsystem consists of a 4×4 array of identical modules. Each module is a hodoscopic array of 96 CsI(Tl) scintillation crystals and associated readout electronics.

Crystals shall meet the mechanical and optical specifications listed below. The crystal dimensional tolerances specified, allow the derived Crystal Detector Elements to be integrated into the supporting structure.

7 REQUIREMENTS

7.1 Mechanical Configuration

The CsI(Tl) crystals shall be rectangular parallelepipeds with a chamfer on the edges of the long dimension.

7.1.1 Finished Crystal Overall dimensions (mm):

Parameter	Maximum Value (mm) at 20 - 25 °C	Minimum Value (mm) at 20 - 25 °C
Crystal Length	326.00	325.40
Crystal Height	19.90	19.50
Crystal Width	26.70	26.30

7.1.2 Chamfered edges. The four long edges of the crystal shall have a 45° chamfer defined by the diagonal distance between two opposing parallel chamfers (as defined in Figure 1), which is necessary for proper fit into the composite structure cell with its elastomeric cords in place.

NOTE: The distance specification opposing parallel chamfers is NOT strictly the diagonal distance of the crystal. As shown in Figure 1, it is the separation of opposing chamfers when projected onto a plane rotated along the long axis by 45 degrees to the plane defined by either the 19.9×326 mm surfaces or 26.7×326 mm surfaces

7.1.3 Surface flatness, parallelism:

7.1.3.1 With the crystal placed on a calibrated surface plate, no point on the crystal face against the flat plane may deviate from the plane by more than 0.20 mm.

7.1.3.2 With the crystal placed on a calibrated surface plate, no point on the crystal face parallel to the plane in contact with the surface plate may deviate from the height requirement of 19.7 mm or the width requirement of 26.5 mm by more than 0.20 mm.

7.1.4 Perpendicularity

7.1.4.1 The end faces of the crystal shall be perpendicular to the side faces and no point shall deviate from the perpendicular by more than 0.3 mm.

7.1.4.2 The adjacent side faces of the crystal shall be perpendicular to each other and no point on one of those sides shall deviate from the perpendicular by more than 0.3 mm.

7.1.5 Surface treatment:

7.1.5.1 Crystals shall have no visible cracks, dents or bumps exceeding the surface flatness specification as specified herein.

7.1.5.2 The two end faces of the crystals shall have a polished finish. The two 26.7mm × 326.0mm side faces shall have a polished finish. The two 19.9mm × 326.0mm faces shall be roughened to provide light taper, except that the final 20 to 60mm of these faces shall be polished. The required light tapering can be verified during the optical performance measurements.

7.1.5.2.1 Alternative surface treatment patterns of polishing and roughening shall be permitted to achieve the required light tapering. Crystals that exhibit treatment patterns other than the nominal pattern specified in section 6.1.6.2 shall have their light tapering curves verified by the Swedish team. Crystals that fail to meet the tapering requirement shall be returned to the manufacturer. Crystals with alternative surface treatment patterns that pass the tapering requirement shall be deemed acceptable.

7.2 Optical Performance

The Swedish team shall provide an optical test bench to verify all required performance measurements. The test bench shall be provided along with documentation and procedures. The Swedish team shall be responsible for providing the Na-22 radioactive source required using the optical test bench. The Swedish team shall provide the mechanical and radioactivity specifications of this Na-22 radioactive source.

7.2.1 Description

The operation of the optical test equipment that are going to be used for measuring optical properties of the CsI crystals for the GLAST calorimeter is defined in LAT-PS-00254-01, " CsI Crystal Optical Test Bench Operating Procedure". The data acquisition and analysis software for the GLAST calorimeter crystal testing station is defined in LAT-SS-00108-02, "CsI Crystal Testing Station Software Requirements".

7.2.2 Light yield

The light yield and its uniformity are specified in terms of the energy resolution for the 511 keV gamma-ray line from a collimated Na-22 source. The 511 keV gamma-ray line measured from each 5 cm diameter photomultiplier tube in contact with the two ends of a crystal log shall have a FWHM (Full Width Half Maximum) of less than or equal to 13% with the source at eleven (11) evenly spaced points starting 2 cm from one end and finishing 2 cm from the other end of the log. During this test the crystals should be surrounded by two layers of reflective white Tyvek

and one layer of aluminum foil. For each crystal, the measurement results shall be provided by Amcrys to the Swedish team, and by the Swedish team to the French team and the Calorimeter Subsystem Office at NRL.

7.2.3 Light Yield Uniformity

The absolute light yield of the array of crystals shall not vary from crystal to crystal by more than 10% of the median value. The absolute light yield of each crystal shall be defined to be the average of the 22 light yields measured at the eleven sampling points identified in section 7.2.2, corrected for instrumental effects of photomultiplier gain. The median value shall be defined as the median of the absolute light yields for the 96 crystals plus spares that comprise each individual tower. These tests will be performed at Amcrys-H and verified by the Swedish team, the French team, and NRL, as appropriate. The results of these measurements shall be included in the data package defined in Section 7.5.

7.2.4 Light Tapering

The light tapering shall be monotonic along the crystal and such that with the source 2 cm from one end the light collected at the far end is 60 ± 10 % of the light collected by the PMT close to the source. Light tapering shall be measured at the same 11 points indicated in 7.2.2.

7.2.5 Light Asymmetry Measure

The change in light asymmetry measure shall be between 0.24 and 0.48 for the two positions closest to ±12 cm from the center of the crystal. The asymmetry measure is defined as the ratio (P-M) / (P+M), where P = 511 keV centroid in the PMT at the “plus” face, and M = 511 keV centroid in the PMT at the “minus” face.

7.2.6 Radiation Hardness

After irradiation with 10 kRad of gamma rays from a Cobalt-60 source the light yield shall not be reduced by more than 50%. The dose rate shall not exceed 2 kRad per hour. The radiation hardness of all crystals in a boule shall be judged by the radiation hardness of a single crystal chosen from that boule. If the sample fails the radiation test, all crystals from that boule will be rejected. The change in light yield shall be judged by the average of the centroids of the 511keV gamma-ray line from Na-22 at the eleven sampling points identified in section 6.2.2. Simultaneously, the radiation hardness of the boule samples shall be measured. Once the correspondence between damage to test crystals and boule samples is established, the boule sample may take the place of the test crystal, and all further radiation hardness studies may be performed solely on the boule samples.

7.3 Mechanical Test Equipment

The Swedish team shall provide a calibrated mechanical test bench France and NRL to verify all required dimensions measurements. The Swedish team shall also provide a copy of the calibration report as well as documentation and procedures for use.

7.3.1 Description

The mechanical test bench and its operation are defined in referenced GLAST document LAT-DS-00096-01, “Calorimeter Crystal Mechanical Test Station Requirements”.

7.4 Visual Inspection

Visual inspection of crystals shall be performed by the Swedish team, the French team, and the NRL team as appropriate. The inspection shall conform to the checklist in Appendix A.

8 CRYSTAL HANDLING PROCEDURE AT SWEDEN

8.1 Transportation from Ukraine to Sweden

Crystals are wrapped in Tyvek and aluminum foil by the manufacturer. Before shipment to Kalmar University in Sweden they are sealed and vacuum packed in plastic bags.

8.1.1 Containers

The vacuum-packed crystals are placed in a wooden tray having 12 slots and being $5\times40\times50$ cm^3 in size. Each slot is made to fit one crystal and is cover with soft elastic material. The tray is covered with a lid that is tightened with screws at X positions along the edge. Two such trays containing 12 crystals each are placed in a larger wooden box and suspended by styrofoam chips. These boxes are $25\times60\times70$ cm^3 in size and equipped with sturdy handles. They are marked for fragile goods and upward direction.

8.1.2 Transportation

The crystals are shipped by the transportation company World Wide Logistics from Ukraine to Kalmar, Sweden. This company has experience in managing transport in Ukraine and has already carried out several transports for GLAST. A procedure for customs clearance has already been established by the company. The transportation from Ukraine usually takes a little less than a week. WWL sends us a notification when they have picked up the goods at Amcrys H and another one when they are ready to deliver in Kalmar.

8.1.3 Notification

Amcrys H will notify the GLAST group at Kalmar University via email as soon as they have packed up the crystals. The message will contain information of when the shipment was picked up, ID numbers of which crystals are housed in which box, and possibly other important information about the transport. As soon as this message is received we will order aluminum mini-plates to be attached to the French V-block crystal cradle (see below).

8.2 Crystal handling upon arrival

Upon delivery the crystal boxes are received by GLAST personnel and signed. Boxes are delivered to the university department by truck, unloaded and placed indoors by the truck driver. The GLAST personnel receiving the goods are signing a recite. The crystal boxes are immediately taken up to the GLAST laboratory on the 3rd floor of the building.

The boxes are not opened until crystals will be visually inspected. When the boxes are opened, the two wooden trays are placed on a table and opened. The individual crystals are placed on another flat table covered with a thin rubber material. The information on location of a crystal in a boule shall be given by drawings showing crystal ID numbers and their locations within a boule.

A delivery of crystals will contain documentation of the test results from the manufacturer and a map over the boule cut identifying the location of each crystal in the delivery. This documentation is filed in the data archive. Ten crystals at a time will be brought into the clean room, where the vacuum sealing will be cut. The wrapping will be removed from only one crystal at a time. To prevent damage to the crystal surfaces, crystals will be handled at all times with powder-free nitrile gloves.

First, a crystal will be visually inspected (see section 8.4) before its mechanical dimensions are measured (see section 8.5). Thereafter the crystal is placed in the dark chamber of the optical test bench. When the chamber's door has been closed a second crystal may be removed from its wrapping and placed in the second optical test bench.

Because the crystal ID number is written on the wrapping and a crystal only can be identified through this number, it is most important to follow a strict procedure according to the following steps. The crystal wrapping will be stored in the dark chamber when the crystal is placed there, not to be disconnected with its crystal. The crystal is put in place firstly, PM tubes are adjusted and then the empty wrapping is placed immediately behind the door, which finally is closed. The crystal ID number is then written on a small white board attached to the outside of the door. Now at first can a second crystal be placed in the second optical test bench in a similar way. After measurement the procedure is reversed. This procedure will guarantee that crystals are not mixed up.

8.3 Inspections and Tests

Each crystal has a serial number assigned to it for traceability and identification, which clearly specifies the boule from which it was manufactured and the location from which it was taken in that boule. The serial number is unique for all crystals purchased for the GLAST calorimeter. The crystal identification number is affixed on the outside of the wrapper in a manner that will not be erased by contact with alcohol. The orientation of the label containing the ID number defines the orientation of the crystal: the characters on the label read from left to right along the long axis of the crystal, and this direction defines the "left" (or "minus") face and the "right" (or "plus") face of the crystal. Furthermore, the labeled face is the "top" face. The polished 26.7×326.0 mm^2 top face is inscribed with a small "V" arrow near to and pointing toward the right face. This right arrow provides a reference orientation for all crystal processing.

Inspections and tests are performed to verify compliance with specification and procedures as specified in this document. Any anomalies during inspection (receiving or in process) or tests will be recorded, and a copy of the report (Nonconformance Material Report) will be sent to the CAL Subsystem Office at NRL.

Calibrated equipment records are maintained in a logbook, and as-run test procedures to account for all inspections and test operations. The entries are complete, self-explanatory, and signed.

Prior to testing, QA will:

- Verify that the applicable inspection and test documents are available;
- Ensure that requirements for and control of crystals have been implemented and that test constraints have been resolved;
- Verify that crystals undergoing test are identified;
- Verify the configuration of the crystals; i.e., crystal ID, date code and lot number
- Verify that the configuration of ground support test equipment (GSE) is consistent with this specification; and
- Verify that the test equipment is calibrated, and such calibration will be effective and sustained during the test period.

During the testing, QA will:

- Ensure that the testing is accomplished in accordance with this specification;
- Ensure that accurate and complete recording of data and test results are performed;
- Document anomalies, nonconformances, and participate in their disposition.

After testing, QA shall:

- Ensure the crystals are stored in their respective boxes.
- All rejected crystals are stored separately.
- Report any additional non-conformances or failures and participate in their disposition;
- Ensure that remedial and preventive action has been accomplished relative to anomalies and non-conformances; and
- Verify that test results and reports are accurate, complete, and traceable to the tested article.
- Ensure that all open anomaly and nonconformance reports are mailed to NRL subsystem office for review and record.

Quality data and records will be stored and maintained in facilities that provide a suitable environment to minimize deterioration, or damage due to fire and to prevent loss. Quality records will be readily retrievable for analysis, trending, and validation.

Prior to release for shipment of crystals, a records review of all open non-conformances will be conducted by the QA department. All non-conformances shall be closed prior to shipment. Documentation will follow a data format provided by NRL. Data will be provided on electronic media to NRL.

For each crystal, mechanical dimensions and optical performance measurements will be shipped along with the crystals. The acceptance data package for each crystal inspected and tested will have at minimum:

- A cover sheet indicating the name, crystal part number, and serial number of the item;
- Mechanical measurements as per section 7.1, will be recorded on Excel files (.xls) on a CD;
- Crystal's optical performance test data as per section 7.2; picture files (.jpg), text file (.txt), Excel file (.xls) from the analysis software and histogram files (.his) from the data acquisition, recorded on the same CD as the mechanical measurements;
- Visual inspection details as per Appendix A;

- Copy of all non-conformance reports, failure reports, waivers, deviations and acceptance test failure documentation applicable to each crystal;
- Electronic outputs of optical test station using the software as specified in LAT-SS-00108-02.

8.4 Visual Inspection

The inspection shall conform to the checklist in Appendix A.

8.5 Mechanical Testing

The measurement of a crystal's mechanical dimensions will firstly be done with a similar equipment to the one used by Amcrys H (and which was provided by Kalmar University). The result will be conferred to the corresponding data obtained from Amcrys H. This equipment is described in document TBD. It contains 12 gauges and measures six points on two opposite faces. By rotating the crystal 90° and repeating the measurement all four large faces of the crystal will be measured. The data will provide information of the distance between and relative inclination of opposing surfaces at three different cross-sectional locations along the crystal. By comparing the measurement with numbers obtained by measuring a reference, further information can be derived about the shape of the crystal surfaces. The reference is a crystal model block precision-made from steel. In addition the largest distance between the end surfaces of the crystal is measured with an electronically read out caliper. In all, the output from this measurement is a list of 50 numbers, six per large crystal face plus the longitudinal measurement makes 25 numbers, each being accompanied by its difference from the corresponding number for the reference.

Second, the crystal will be mechanically measured by using a second device provided by the French GLAST group at Saclay. This equipment measures the minimum distance between to parallel flat surfaces that the crystal fits in between. By placing the crystal in a V-block with a 45° tilt, also the parallel distance between opposing chamfer surfaces can be measured. The device also has gauges that measure the relative distance and inclination of the chamfer surfaces to a parallel plane in between, which location is defined by the corner of the V-block, i.e. the two surfaces of the crystal it is resting on. This equipment also measures the length of the crystal.

8.6 Optical Testing

The optical measurement of the light output from the crystal as a function of longitudinal position of the radioactive source used as a standard candle is described in document TBD.

8.7 Data Exchange

Data from the optical measurements will be in the form of picture files (.jpg), text files (.txt), and Excel files (.xls) from the analysis of the light yield, plus the histogram files (.his) from the data acquisition. Data from the mechanical measurements will be available in an Excel file (.xls).

For each shipped box of crystals, there will be a CD with measured data onside the box. On each CD, each crystal will have a separate folder.

9 QUALITY CONTROL AND INSPECTION

Amcrys-H shall monitor, control and maintain process parameters to ensure that the CsI(Tl) crystal characteristics fall within required specifications and/or tolerances as specified herein. Amcrys shall establish and follow documented procedures for inspection activities to verify that the product requirements are met.

9.1 Crystal Traceability and Identification

9.1.1 Purpose

Each crystal shall have a serial number that clearly specifies the boule from which it was manufactured and the location from which it was taken in that boule. The serial number shall be unique for all crystals purchased for the GLAST CAL.

9.1.2 Implementation

The crystal identification number shall be affixed on the outside of the wrapper in a manner that will not be erased by contact with alcohol. The orientation of the label containing the ID number shall define the orientation of the crystal: the characters on the label read from left to right along the long axis of the crystal, and this direction shall define the "left" (or "minus") face and the "right" (or "plus") face of the crystal. Furthermore, the labeled face shall be the “top” face. During crystal inspection in Kalmar, the polished 26.7 mm x 326.0 mm top face shall be inscribed with a small “V” arrow near to and pointing toward the right face. This right arrow shall provide a reference orientation for all further crystal processing.

The information on location of a crystal in a boule shall be given by drawings showing crystal ID numbers and their locations within a boule.

Controls shall be established to ensure that:

1. Serial numbers are assigned in a systematic and consecutive manner.
2. Serial numbers of scrapped or destroyed items are not used again.
3. Serial numbers, once allocated, are not changed or repeated.
4. Supporting documentation and the delivery data package for each crystal shall be identified by the crystal serial number.

9.2 Crystal Contamination Control after Final Polish

To prevent damage to the crystal surfaces after final surface treatment, crystals shall be handled at all times with powder-free nitrile gloves.

9.3 Inspection and Testing

Inspections and tests shall be performed to verify compliance with specification and procedures as specified herein. The inspection and tests should be repeated by the Swedish team on procured crystals using similar test equipment and controlled hardware. These inspections shall include mechanical and optical tests as defined herein. These activities shall be monitored or witnessed as necessary by QA. Any anomalies during inspection (receiving or in process) or tests shall be recorded, and a copy of the report (Nonconformance Material Report) shall be sent to the CAL Subsystem Office at NRL.

Calibrated equipment records shall be maintained in a logbook, and as-run test procedures to account for all inspections and test operations. The entries shall be complete, self-explanatory, and signed.

Prior to testing, QA shall:

- Verify that the applicable inspection and test documents are available;
- Ensure that requirements for manufacturing process and control of crystals have been implemented and that test constraints have been resolved;
- Verify that crystals undergoing test are identified;
- Verify the configuration of the crystals; i.e., crystal ID, date code and lot number
- Verify that the configuration of ground support test equipment (GSE) is consistent with this specification; and
- Verify that the test equipment is calibrated, and such calibration will be effective and sustained during the test period.

During the testing, QA shall:

- Ensure that the testing is accomplished in accordance with this specification;
- Ensure that accurate and complete recording of data and test results are performed;
- Document anomalies, nonconformances, and participate in their disposition.

After testing, QA shall:

- Ensure the crystals are stored in their respective boxes.
- All rejected crystals are stored separately.
- Report any additional non-conformances or failures and participate in their disposition;
- Ensure that remedial and preventive action has been accomplished relative to anomalies and non-conformances; and
- Verify that test results and reports are accurate, complete, and traceable to the tested article.
- Ensure that all open anomaly and nonconformance reports are mailed to NRL subsystem office for review and record.

9.4 Control of Quality Records

Quality data and records shall be stored and maintained in facilities that provide a suitable environment to minimize deterioration, or damage due to fire and to prevent loss. Quality records shall be readily retrievable for analysis, trending, and validation.

Prior to release for shipment of crystals, a records review of all open non-conformances shall be conducted by the QA department. All non-conformances shall be closed prior to shipment.

9.5 Acceptance Data Package and Documentation

For each crystal, mechanical dimensions, optical performance measurements as specified herein, shall be shipped along with the crystals. Documentation shall follow a data format provided by NRL. Data shall be provided by Sweden and France on electronic media to NRL.

The acceptance data package for each crystal inspected and tested will have at minimum:

- A cover sheet indicating the name, crystal part number, and serial number of the item;
- Mechanical measurements as per section 7.1;
- Crystal's optical performance test data as per section 7.2;

- Visual inspection details as per section 7.4
- Copy of all non-conformance reports, failure reports, waivers, deviations and acceptance test failure documentation applicable to each crystal;
- Electronic outputs of optical test station using the software as specified in LAT-SS-00108-02.

10 HANDLING

At all times and during all processes, crystals shall be handled according to Calorimeter CsI Crystal Handling and Shipping Procedure, LAT-PS-00809-01.

11 FACILITIES REQUIREMENTS

All operations shall be performed in a class 100,000 or equivalent clean room environment with temperature and humidity controls as specified in GLAST LAT Calorimeter Contamination Control Plan, LAT-MD-00228.

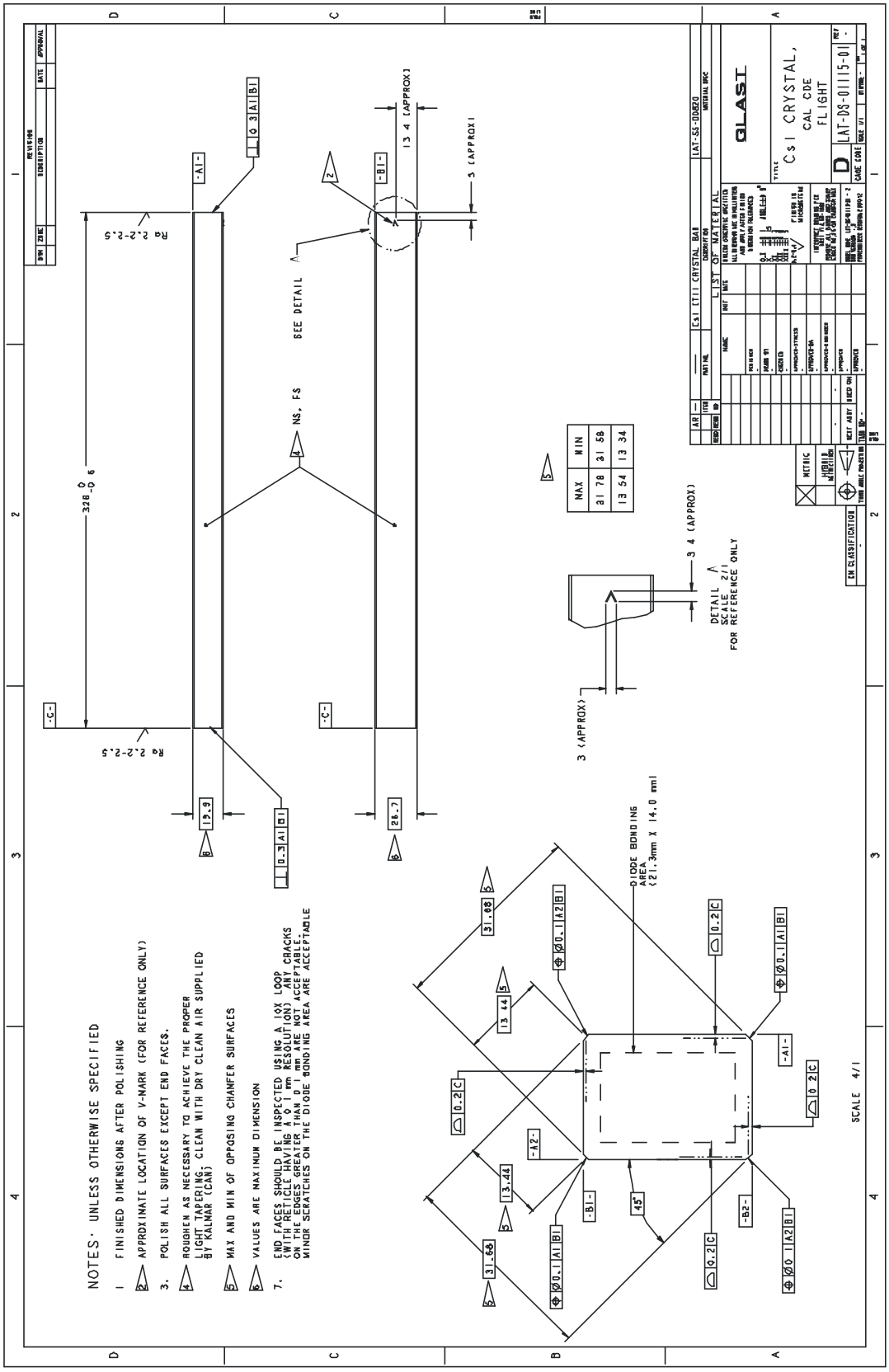

Figure 1. CsI Crystal Polished Dimensions and Tolerances, LAT-DS-01115

APPENDIX A

Inspection Checklist

EM Crystal Visual Inspection Checklist

Item Description Engineering Model CsI Crystal	**Part Number:**	**Serial Number:**	**Accepted** ☐	**Rejected** ☐
Received From:	**Quality Assurance Manager** Name: Date:		**Inspection Performed By** Name: Date:	
Received Date:				

VISUAL INSPECTION To be performed under 1 – 10X magnification. Mark anomalies on attached crystal drawing. Arrow scratch defines “top” and “right” xtal orientation. Long side faces are denoted “top fat”, “front skinny”, “bottom fat”, and “back skinny.”	**Yes**	**No**	**Reject**	**Remarks**
SHIPPING WRAPS AND SUPPORT Vacuum bagging Tyvek and aluminum foil wrap material Tyvek and aluminum foil end caps Wrap sealed with Acrylic base Kapton tape Aluminum supporting sleeve	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	
CRYSTAL SIZE Approximately 326 x 27 x 20 mm	☐	☐	☐	
CRYSTAL ORIENTATION FIDUCIAL MARK “Arrow” scratch exists near one end of fat side	☐	☐	☐	
CRYSTAL CLARITY Clear Milky, cloudy	☐ ☐	☐ ☐	☐ ☐	
CHAMFERS Chamfers present, approximately as per dwg Sharp edges on chamfers	☐ ☐	☐ ☐	☐ ☐	
INTERNAL DEFECTS Dark inclusions White or light inclusions Crystal domains or visual distortion Other defects (describe)	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	

"Top Fat" side

VISUAL INSPECTION To be performed under 1 – 10X magnification. Mark anomalies on attached crystal drawing.	**Yes**	**No**	**Reject**	**Remarks**
SURFACE TREATMENT Polished	☐	☐	☐	
SURFACE DEFECTS Chips Scratches Globs Pits Surface domains, "cellular" structure Machining marks Smudges Tape marks Other surface defects (describe)	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	
SURFACE FLATNESS Flat against surface plate Lifting at left end Lifting at right end Other flatness defects (describe)	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	

"Bottom Fat" side

VISUAL INSPECTION To be performed under 1 – 10X. Mark anomalies on attached crystal drawing.	**Yes**	**No**	**Reject**	**Remarks**
SURFACE TREATMENT Polished	☐	☐	☐	
SURFACE DEFECTS Chips Scratches Globs Pits Surface domains, "cellular" structure Machining marks Smudges Tape marks Other surface defects (describe)	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	

SURFACE FLATNESS Flat against surface plate Lifting at left end Lifting at right end Other flatness defects (describe)	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	

"Front Skinny" side

VISUAL INSPECTION To be performed under 1 – 10X magnification. Mark anomalies on attached crystal drawing.	**Yes**	**No**	**Reject**	**Remarks**
SURFACE TREATMENT Roughened, except near ends	☐	☐	☐	
SURFACE DEFECTS Chips Scratches Globs Pits Surface domains, "cellular" structure Machining marks Smudges Tape marks Other surface defects (describe)	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	
SURFACE FLATNESS Flat against surface plate Lifting at left end Lifting at right end Other flatness defects (describe)	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	

"Back Skinny" side

VISUAL INSPECTION To be performed under 1 – 10X magnification. Mark anomalies on attached crystal drawing.	**Yes**	**No**	**Reject**	**Remarks**
SURFACE TREATMENT Roughened, except near ends	☐	☐	☐	

SURFACE DEFECTS Chips Scratches Globs Pits Surface domains, “cellular” structure Machining marks Smudges Tape marks Other surface defects (describe)	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	
SURFACE FLATNESS Flat against surface plate Lifting at left end Lifting at right end Other flatness defects (describe)	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	

Left end face

VISUAL INSPECTION To be performed under 10X magnification (10X loop with a reticle having a 0.1mm resolution). Mark anomalies on attached crystal drawing.	**Yes**	**No**	**Reject**	**Remarks**
SURFACE TREATMENT Polished	☐	☐	☐	
SURFACE DEFECTS - Any cracks on the edges having a width or length greater than 0.1mm are unacceptable - Only minor scratches on the diode bonding area are acceptable Chips Scratches Globs Pits Surface domains, “cellular” structure Machining marks Smudges Tape marks Other defects (describe)	 ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	 ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	 ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	

Right end face

VISUAL INSPECTION To be performed under 10X magnification (10X loop with a reticle having a 0.1mm resolution). Mark anomalies on attached crystal drawing.	**Yes**	**No**	**Reject**	**Remarks**
SURFACE TREATMENT Polished	☐	☐	☐	
SURFACE DEFECTS - Any cracks on the edges having a width or length greater than 0.1mm are unacceptable - Only minor scratches on the diode bonding area are acceptable				
Chips	☐	☐	☐	
Scratches	☐	☐	☐	
Globs	☐	☐	☐	
Pits	☐	☐	☐	
Surface domains, “cellular” structure	☐	☐	☐	
Machining marks	☐	☐	☐	
Smudges	☐	☐	☐	
Tape marks	☐	☐	☐	
Other defects (describe)	☐	☐	☐	

Indicate the observed crystal anomalies on the following drawings. Drawings are oriented as indicated, with crystal Left on the left, and crystal Right on the right.